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OBSERVATIONS OF THE RED SPOT ON JUPITER

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and

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Research Center
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OBSERVATIONS OF THE RED SPOT ON JUPITER

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Photographic observations of the Red Spot on Jupiter have been made on 33 dates between June 1962 and January 1963. The photographs, taken unfiltered on blue plates (usually Eastman III-0, but occasionally II-0 or IV-0), were obtained with the Research Center's 12-inch reflector* using the 20-meter Cassegrainian focus.

Each plate contains 62 images taken at 30-second intervals, with the over-all time interval centered on the estimated transit time of the center of the Red Spot across the central meridian of Jupiter. The photographic schedule and the estimated transit times were determined by a preliminary ephemeris based on observations during 1961. Because of conflicting photographic schedules, the Red Spot coverage was somewhat incomplete during the first four months. Poor weather limited observations during October 1962 to three dates. As backup for the photographic program, visual observations of transit times and general appearance of Jupiter were made by one of us (C.W.T.) with a reflector of 16 inches aperture.

Each of the 33 plates has been examined for general appearance of the planet in blue light, and estimates have been made of the exact transit time of the center of the Red Spot across the central meridian. Additionally, certain features on some of the better plates have been examined with a microphotometer.

Both of the writers made two estimates each (separated by several days) of the transit image on each of the plates, with the plate set up to indicate direct motion of the Red Spot across the disk, i.e., with the emulsion away and south at the top as the planet would be seen at the eyepiece of the telescope. With the appropriate times recorded, the process was repeated with inverted images, i.e., with the plate set up to indicate retrograde motion of the Red Spot across the disk. This technique served to establish the systematic subjective errors in the estimation of the particular image taken at the true transit times. The differences in the selected time (averages of two estimates each) between the direct and inverted setups for the two writers is shown in Figure 1. It is assumed that the true transit time is the average of the times chosen for the direct and inverted presentations. When the averages of the two writers were compared, it was found that the mean disagreement between them amounted to only 1.5 minutes or 0.9 degrees of longitude.

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*This instrument was made available to the New Mexico State University by the United States Army Research Office (Durham).

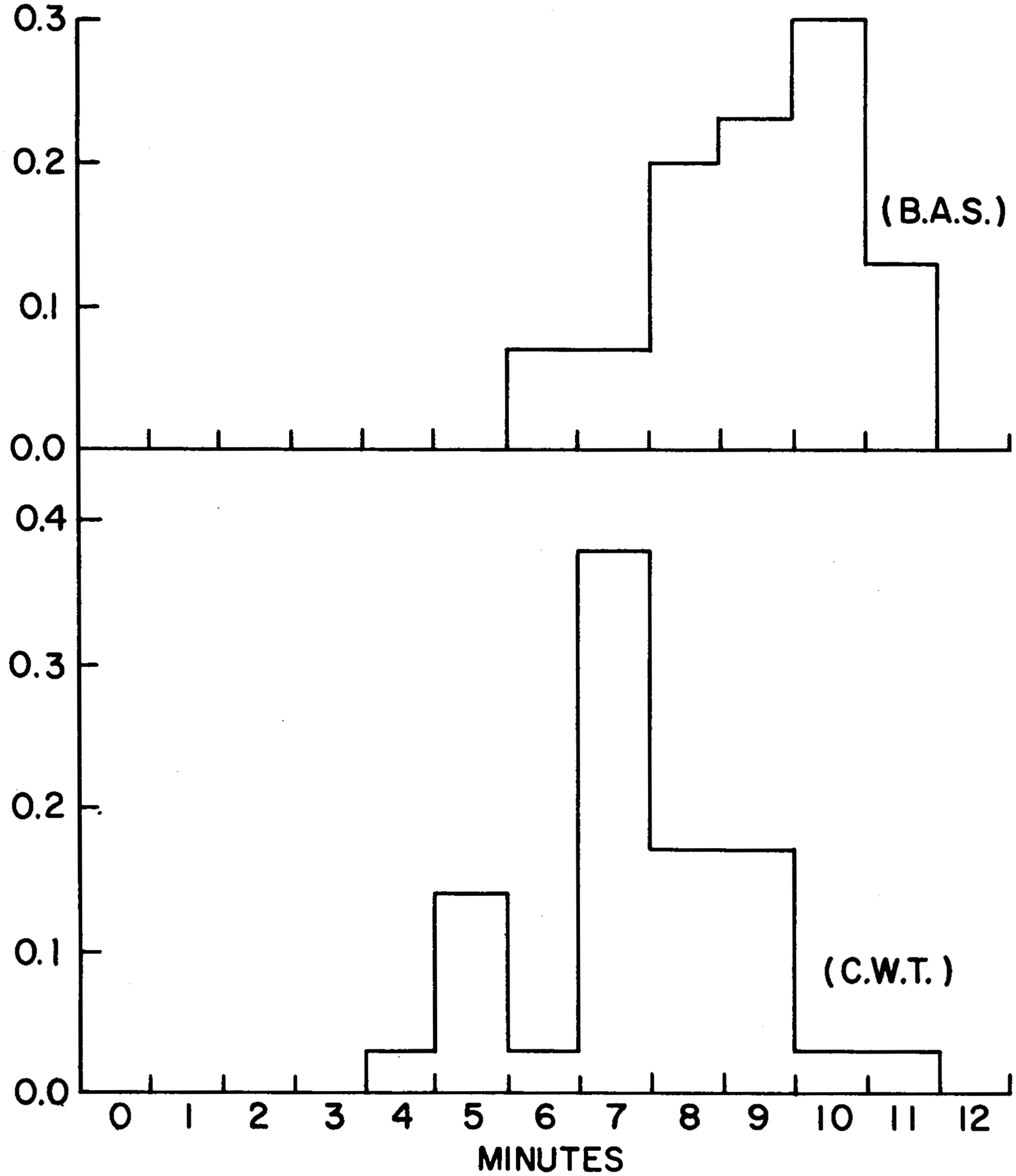

Figure 1. Normalized distribution of the differences between direct and inverted plate presentation for estimated Red Spot transit times by the two writers (see text).

It can be seen that the systematic subjective errors are 3-1/2 and 4-1/2 minutes respectively for C.W.T. and B.A.S., and it is interesting to note that these errors represent early estimations in transit time (Red Spot too far to the right) for both writers.

The average transit time for each date was then converted to the proper System II longitude of Jupiter. (The apparent decentering of the illuminated disk at appreciable phase angles has, of course, been taken into consideration.) Figure 2a gives the corresponding results, with the System II longitude of the Red Spot plotted against the date of observation. Figure 2b shows the same parameters as derived from the visual observations. It will be noted that visual observations average approximately 2-1/2 degrees less in longitude, corresponding to a systematic subjective error of -4 minutes, in fair agreement with value obtained above. Since Figure 2a actually represents the average of eight estimates, while Figure 2b represents only a single selection of time, the former is given the greater weight. The System II longitude of Red Spot as function of time, shown in Figure 2a, suggests two successive rates of rotation as an approximation for a description of its motion. Although non-linear terms may actually be present, the scatter of the points precludes such an analysis. Thus it was decided to employ least-squares solutions for the determination of the linear rates with respect to the System II coordinate system, before and after the apparent change in early November. These rates along with their standard deviations are included in Figure 2a.

It will be noted that the System II longitude of the Red Spot was increasing at the rate of 0.058 $\pm$ .005 degrees per day, corresponding to a rotation period of $9^h55^m43.1^s \pm 0.2$ or 2.5 $\pm$ 0.2 seconds longer than the established period of $9^h55^m40.632^s$ for System II, from June 1962 until approximately 10 November 1962. On or near this date the Red Spot appears to have been accelerated. From then on, until the middle of January 1963, the longitude of the spot was increasing at a rate of 0.025 $\pm$ 0.008 degrees per day, corresponding to a rotation period of $9^h55^m41.7^s \pm 0.3$ or 1.4 $\pm$ 0.4 seconds shorter than before. The abrupt change indicated on 10 November should obviously not be taken to represent the true physical picture. Rather, the change in angular velocity undoubtedly took place over several days or possibly weeks.

In order to speculate as to the cause of this relatively sudden change in the rotation rate of the Red Spot, the general appearance of Jupiter throughout the seven-month period of observation will be summarized: The coarser features in the longitudes near the Red Spot remained essentially unchanged in blue light from June until late October or early November 1962. Figure 3a is typical of the appearance in blue light while Figure 3b indicates the general appearance of the planet in red light during July and August. (The number of red plates taken from June through January is insufficient to adequately discuss the planet at these wavelengths.) Visually, Jupiter showed a slightly reddish brown equatorial region with grey or slightly bluish dark belts in the mid-latitudes. The polar regions were grey. On or about 10 August, one of three long-lived bright oval spots in the North Temperate

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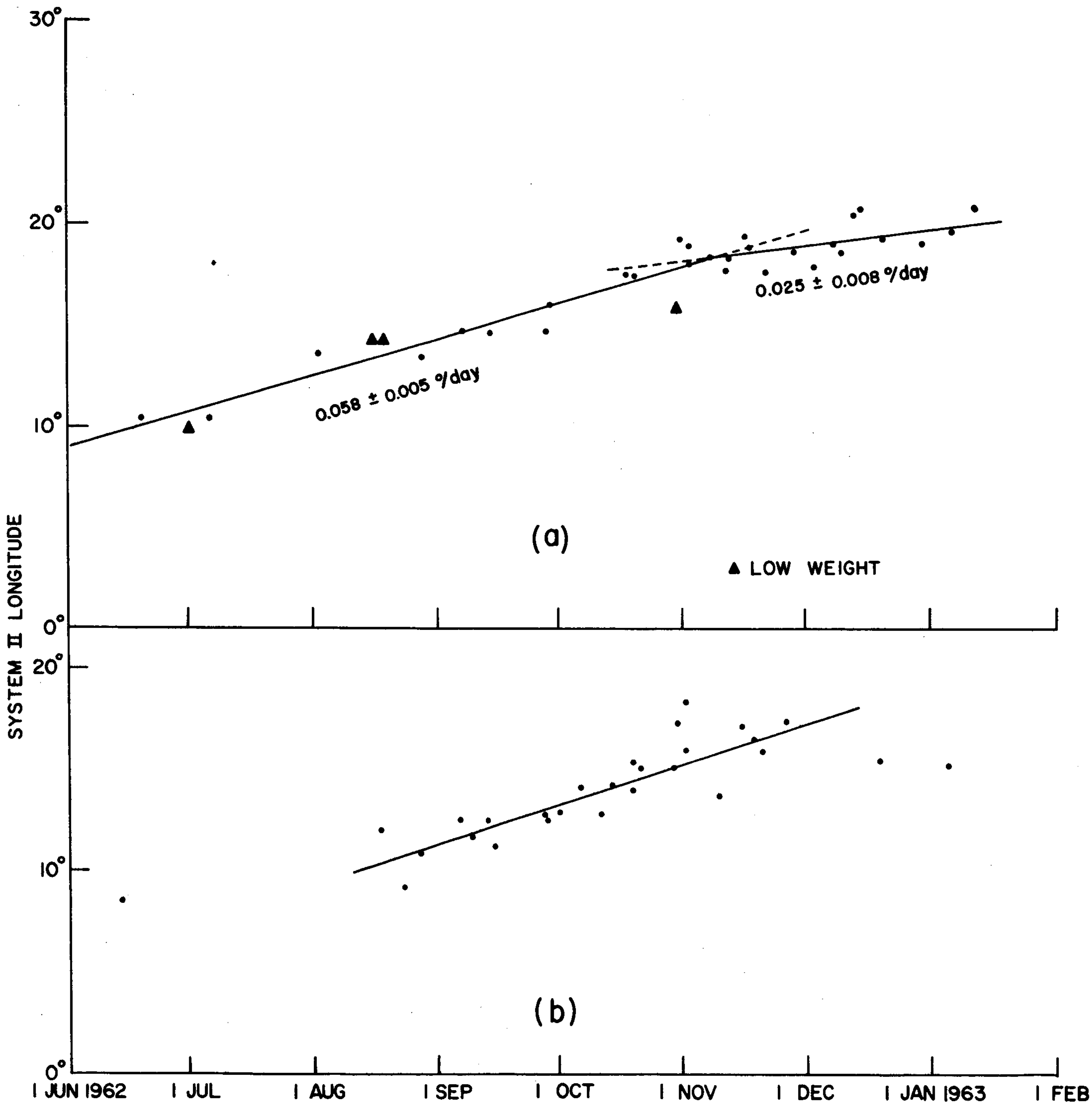

Figure 2. Estimates of the System II longitude of the Red Spot. (a) Red Spot longitudes taken from photographic plates. Drift rates with respect to System II are indicated. (b) Red Spot longitudes derived from visual observations.

Belt* approached the following end of the Red Spot. These spots which have been observed continuously since their formation in 1940 have an average period of rotation approximately 30 seconds less than that of System II (see Peek, 1958). With its considerably shorter rotation period, this spot overtook the Red Spot, passing along the southern edge, and left the preceding end about 25 September. No changes in the appearance of the Red Spot were noted. At some time around 10 November another of these three white oval spots approached the following end of the Red Spot, passed along the southern edge, and left the preceding end about 1 January 1963. This time definite changes were taking place, including the above noted change in rotation period. Nevertheless it is not believed that the Red Spot acceleration was due to the second bright spot, since the first apparently had no effect.

On 24 September a major disturbance broke out at longitude 234° (System II) in the South Equatorial Belt (extends along a latitude equal to the northern boundary of the Red Spot) and spread rapidly in increasing and decreasing longitudes. By the end of October bright and dark spots were photographed approaching the preceding end of the Red Spot. Although the actual date of encounter is uncertain, there can be but little doubt that contact was established by the end of the first week of November. At about this same time the previously weak southern component of the South Equatorial Belt following the Red Spot, began to develop. The bright South Tropical Zone, at the same latitude as the middle of the Red Spot, began to darken in the longitudes preceding the spot. By December the whole South Equatorial Belt in the vicinity of the Red Spot showed the appearance of extreme turbulence, as may be seen in Figure 3c. The South Equatorial Belt Zone (a bright belt between the two dark components) had become considerably darker by the end of December.

Figure 4 shows photometric measurements made on selected plates throughout the observing period. Here the brightness, in blue light, of the Red Spot and the South Equatorial Belt Zone are given in terms of unit brightness for the equatorial zone. Note that the slight darkening of the Red Spot after the first of December is far more subtle than the decline in brightness of the South Equatorial Belt Zone, apparently starting in mid-October. Past observations by others (see Peek, 1958) have indicated that the Red Spot tends to fade following a South Equatorial Belt disturbance. As of mid-January 1963, no indication of this phenomenon had been observed.

The Red Spot has changed its rate many times in the past. There is no definite evidence that this observed acceleration was directly related to the disturbance in the South Equatorial Belt. Only the coincidence of occurrence of events can lead to a suggestion of an intrinsic relationship. Clearly the need for continued observations is indicated.

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*The North Temperate Belt (this and other features to be mentioned utilizes nomenclature adopted by the Association of Lunar and Planetary Observers and the British Astronomical Association, [see Peek, 1958]) extends along a latitude equal to the southern extremity of the Red Spot.

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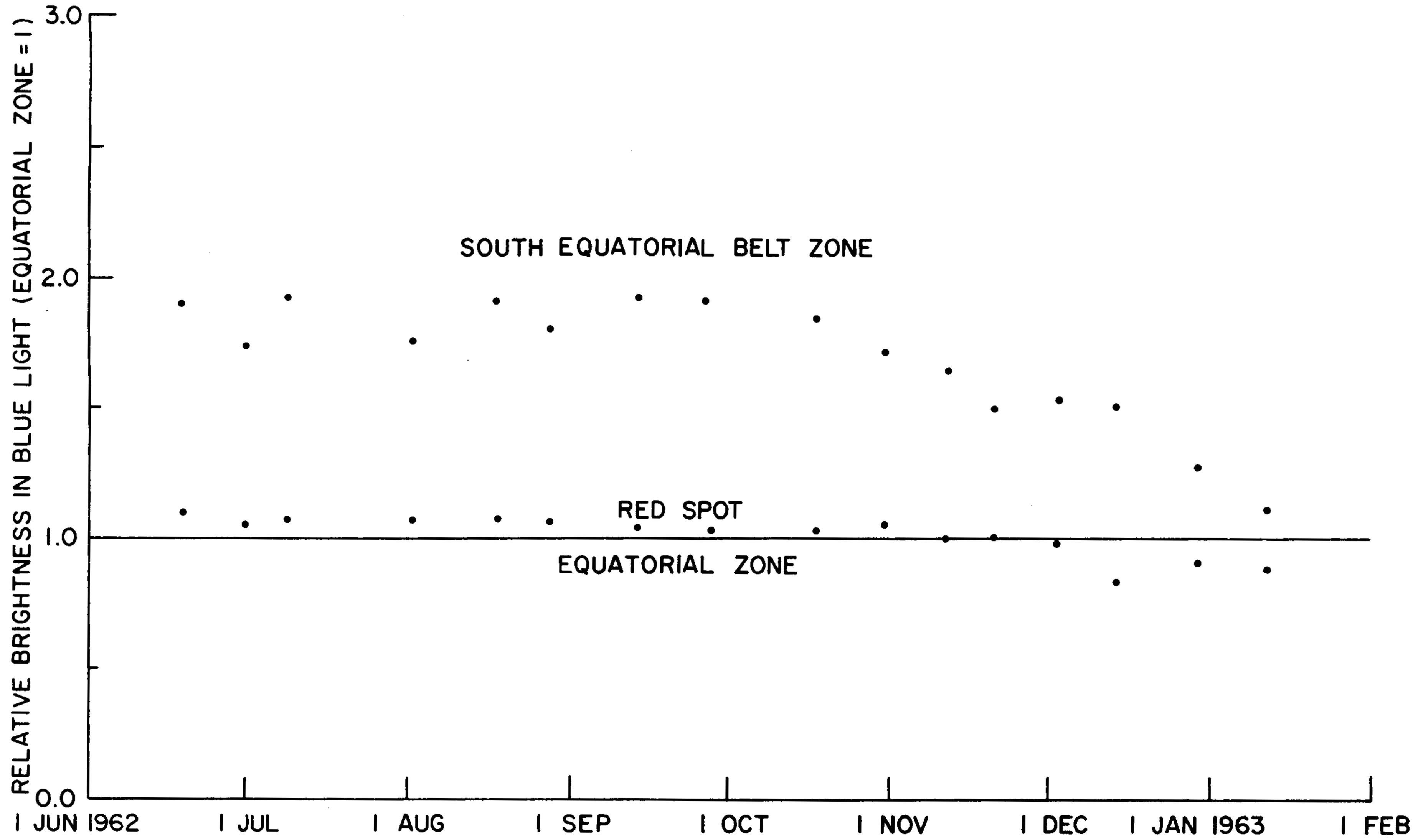

Figure 4. Photometric measurements of the brightness in blue light of the Red Spot and South Equatorial Belt Zone with respect to the Equatorial Zone.

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